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An Experimental Space Surveillance RADAR Transponder for the RAFT1 CubeSat



**Anthony Monteiro, AA2TX &
Bob Bruninga, WB4APR
for the XP217 team**

AMSAT Space Symposium, 2004

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Navy Space Surveillance System

- **VHF RADAR**
- **Designed to detect and track LEO objects**
- **Primary mission is space defense**
- **Also provides data to NORAD which generates Keplerian elements**

NSSS RADAR system

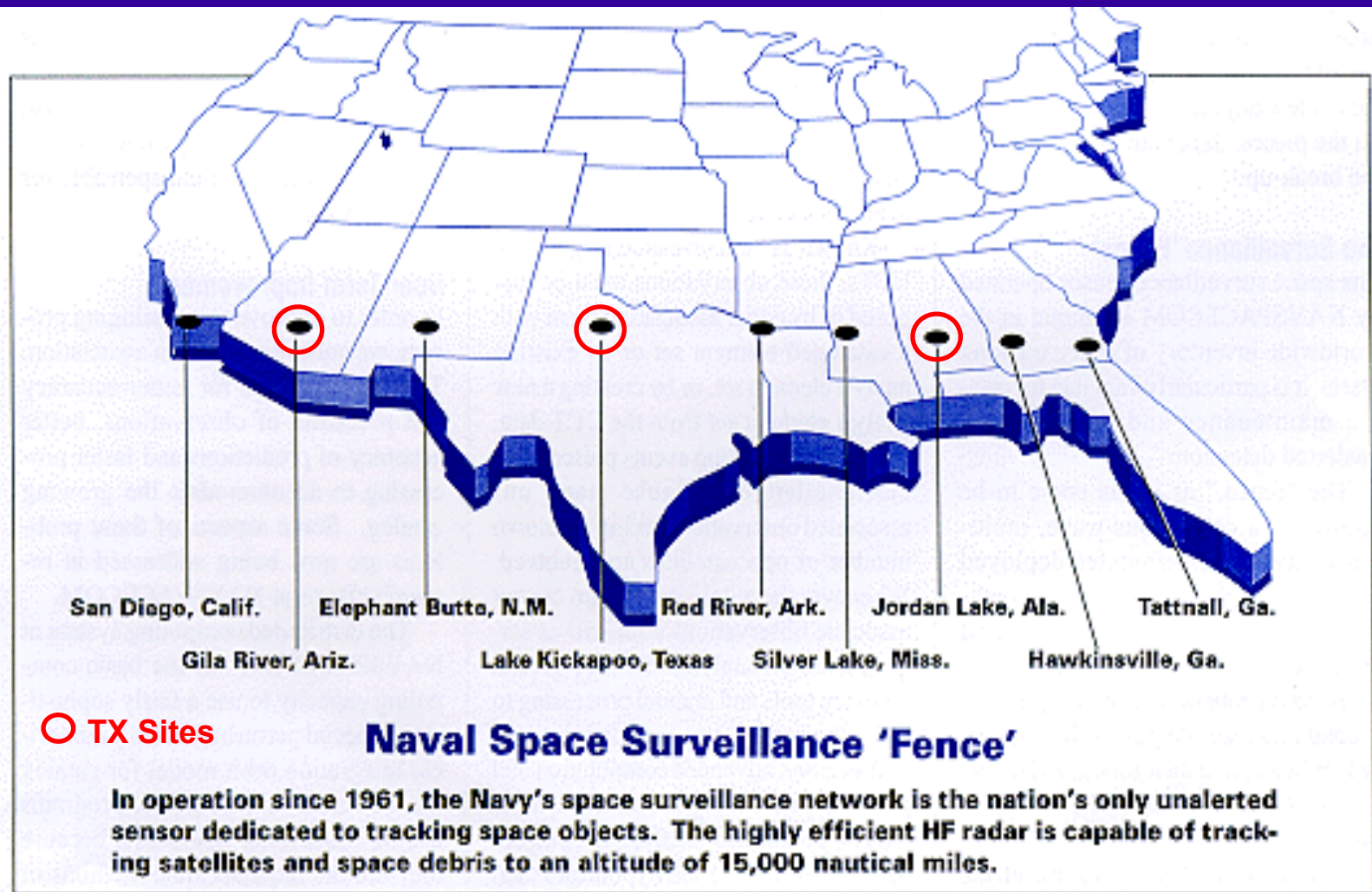
- **CW RADAR**
- **Three transmitter sites**
- **Transmitters generate a non-steerable, east-west oriented fan-beam**
- **Very narrow fan-beam is called the NSSS “Fence”**

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NSSS RADAR “Fence”



NSSS “Fence”



NSSS Fence - Main Transmitter

- Located at Lake Kickapoo, TX
- Operates at 216.98 MHz
- Antenna is nearly 2 miles long consisting of 2556 inverted V elements
- EIRP is > 6 Billion Watts

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Lake Kickapoo Antenna



NSSS Receiving Stations

- Six receiving stations
- Detect echo's when objects cross the "Fence"
- Interferometer antenna captures amplitude and phase information
- Receivers have $> 28\text{KHz}$ bandwidth

NSSS Receiving Antenna



San Diego Receiving Site, 1993. "That big, round, horizontal pipe is a coax!"

Photo by T. Kneisel

NSSS RADAR system

- **Currently tracking over 10,000 objects**
- **Can detect objects up to 15,000 miles altitude**
- **Designed to detect objects as small as 12 inches in diameter**

Tracking Problem

- **CubeSats, PicoSats, NanoSats etc. are less than 12 inches in diameter!**
- **NSSS RADAR has difficulty distinguishing small satellites**
- **Accurate Keplerian element generation is delayed**

Lost in Space...

“Now we have another great launch where eight microsat's were placed into orbit, and everyone is scrambling to come up with some Keps that reflect who is who up there.

...

I can recall from last years launch that it took the better part of a MONTH before it was settled...”

- From the AMSAT-Bulletin Board 29-JUN-2004.

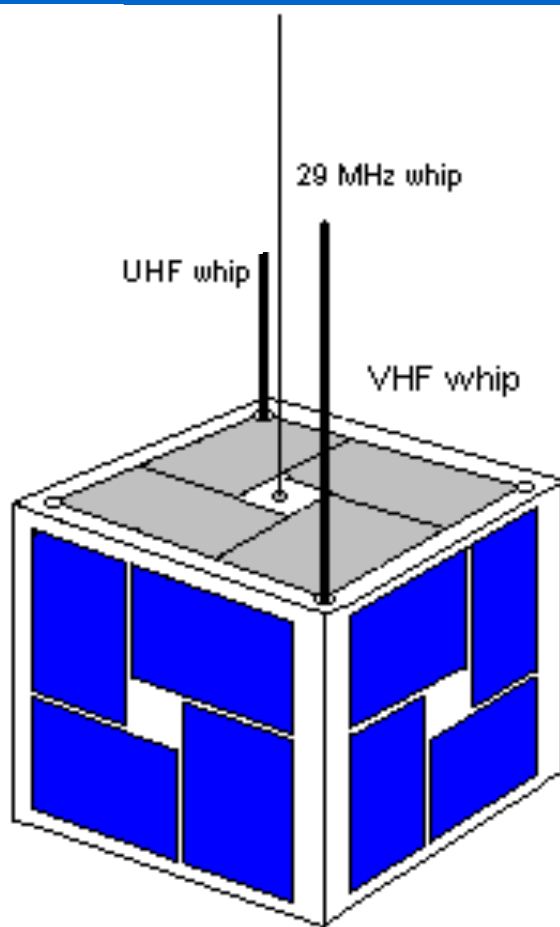
CubeSat Fence Experiment

- Provide a 217 MHz beacon transmitter on a CubeSat
- Provide an on-board receiver to allow detection of the NSSS RADAR “Fence” beam
- Approved by DOD Space Experiments Review board Fall 2002

RAFT1 CubeSat

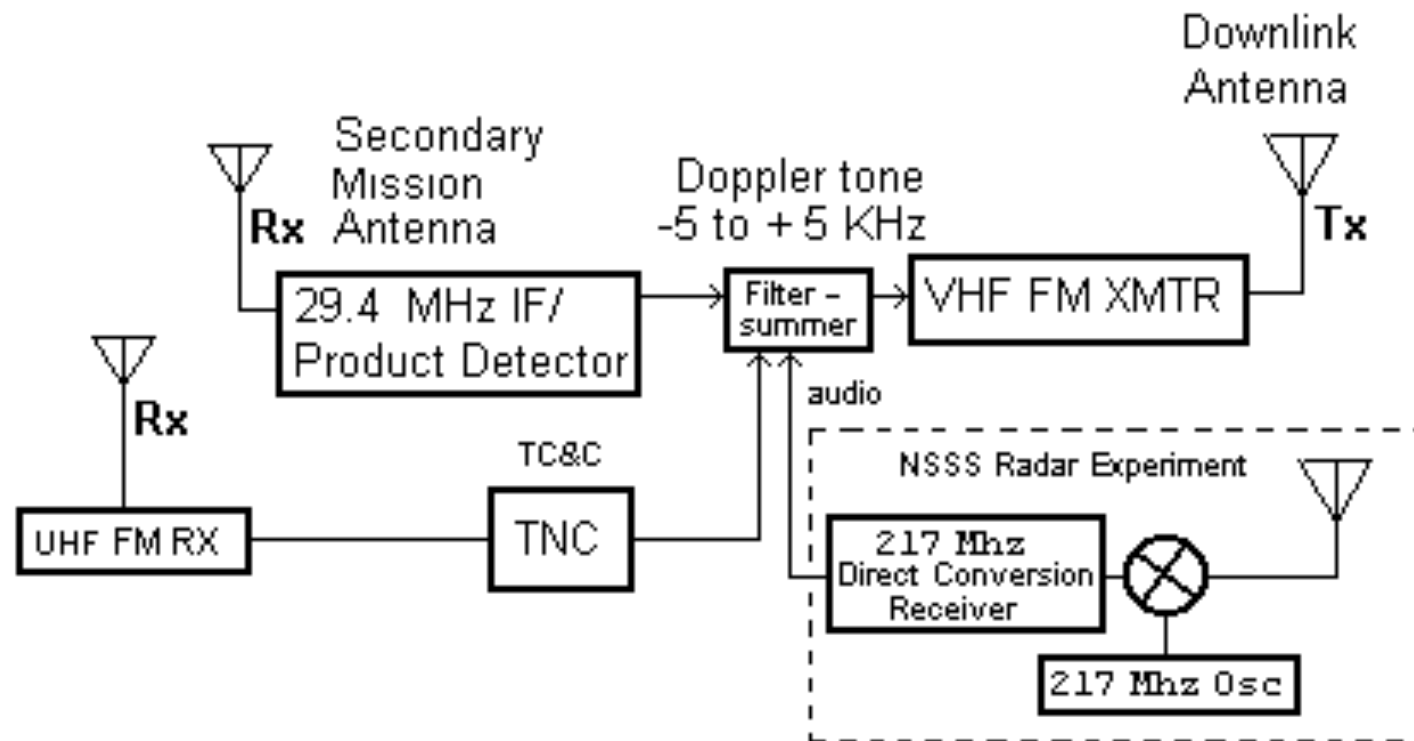
- **R**ADAR **F**ence **T**ransponder
- Developed by the US Naval Academy Satellite Lab, Bob Bruninga, WB4APR
- Being designed and built by USNA students
- Includes amateur radio payload

RAFT1 - CubeSat



- **Uplinks**
 - 435.275 MHz FM AX.25 Packet
 - 29.4 MHz PSK-31
- **Downlink**
 - 145.825 MHz FM AX.25 Packet and PSK-31

RAFT1 - Block Diagram



XP217 RADAR Transponder

- Being developed by Boston area AMSAT members: David Goncalves, W1EUJ, Joe Fitzgerald, KM1P and Tony Monteiro AA2TX
- NSSS RADAR “Fence” assistance from Tom Kneisel K4GFG

First XP217 Meeting in Boston

Joe KM1P

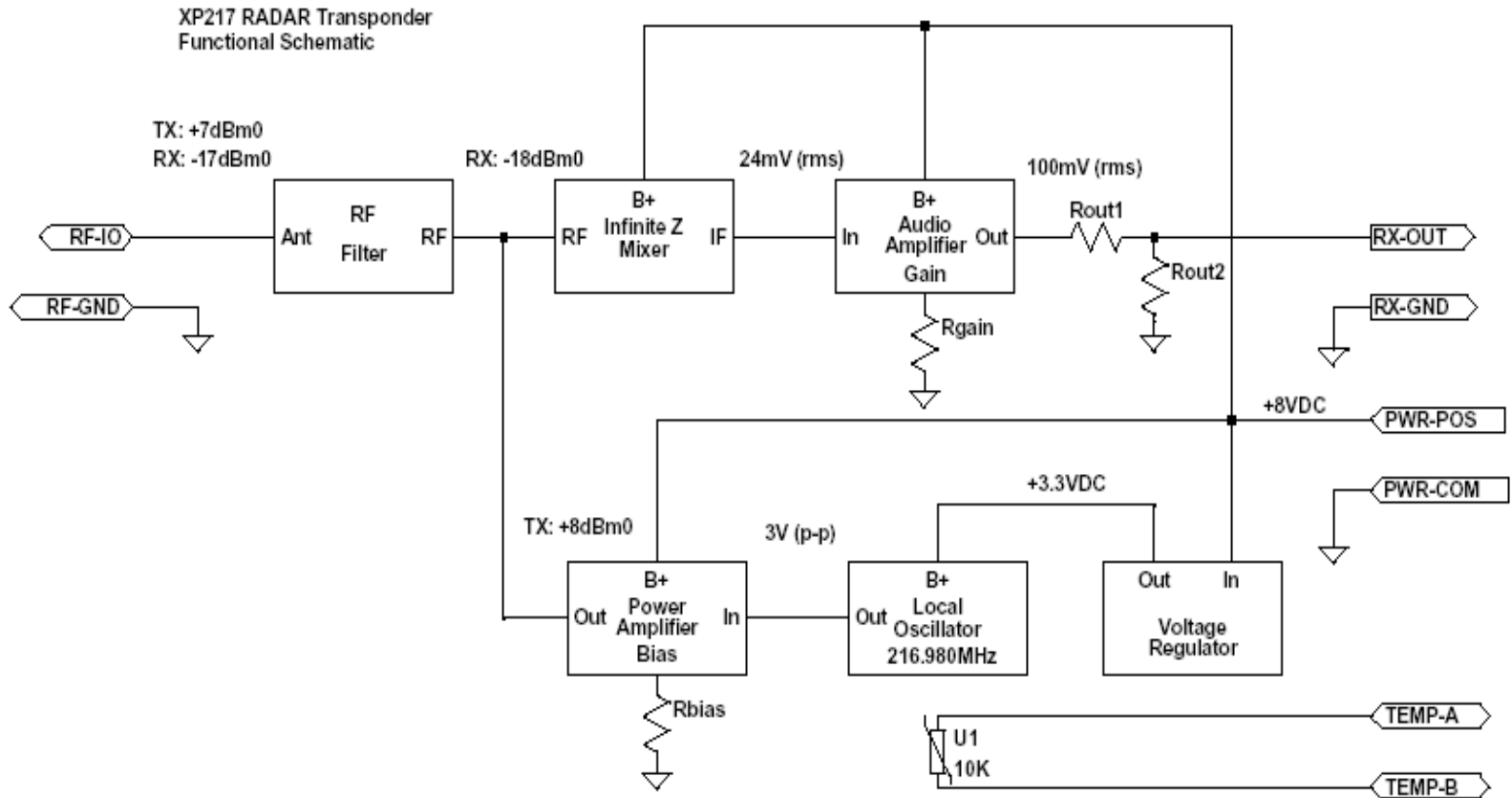
David W1EUJ



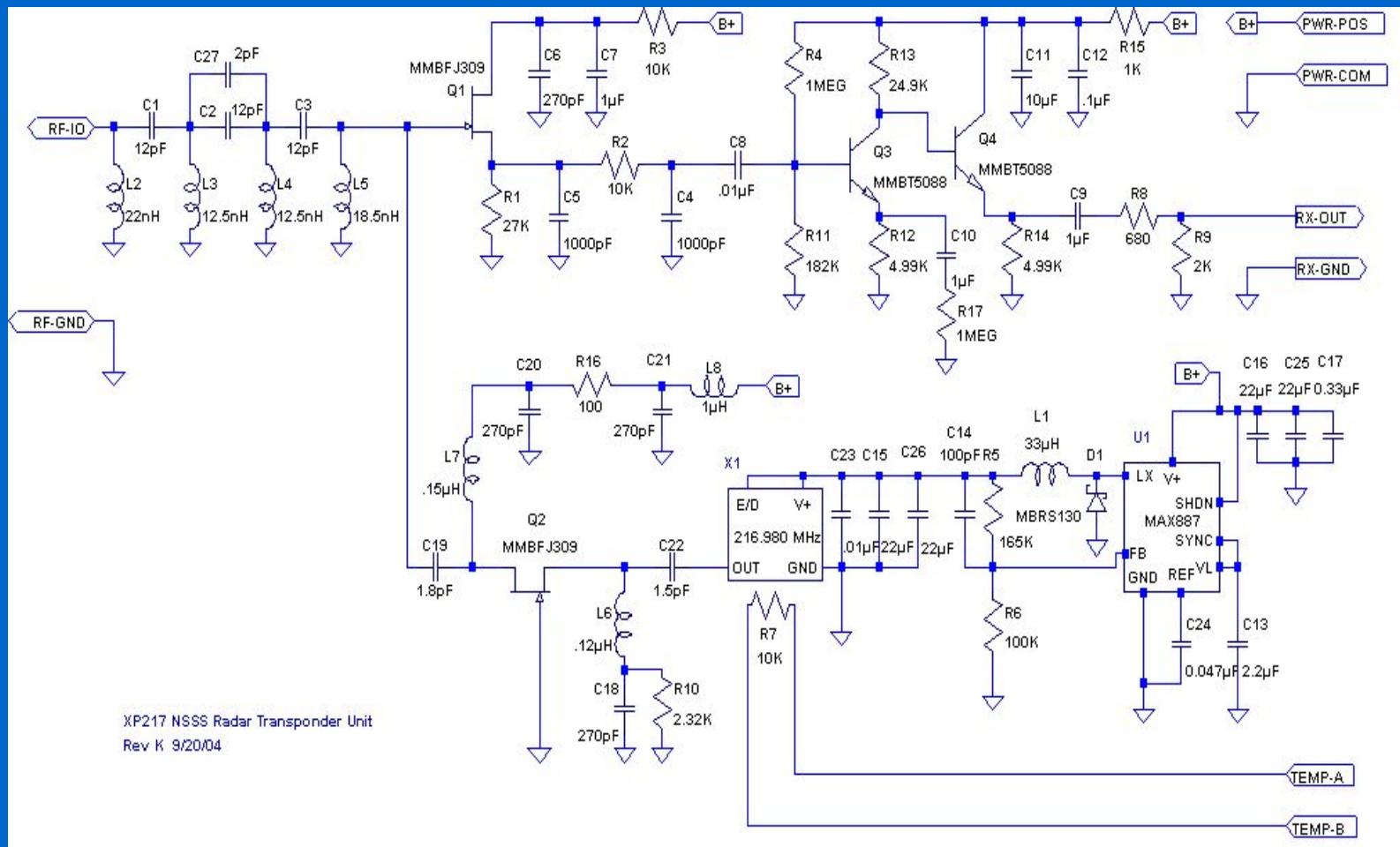
XP217 Design Goals

- “Match box” size
- Max current drain of 50 mA at 8 VDC
- Transmit at +6dBm0 EIRP
- Receive “Fence” signal at $\sim -30\text{dBm0}$
- Simultaneous transmit and receive
- Inexpensive – potential use on future CubeSats

XP217 Architecture

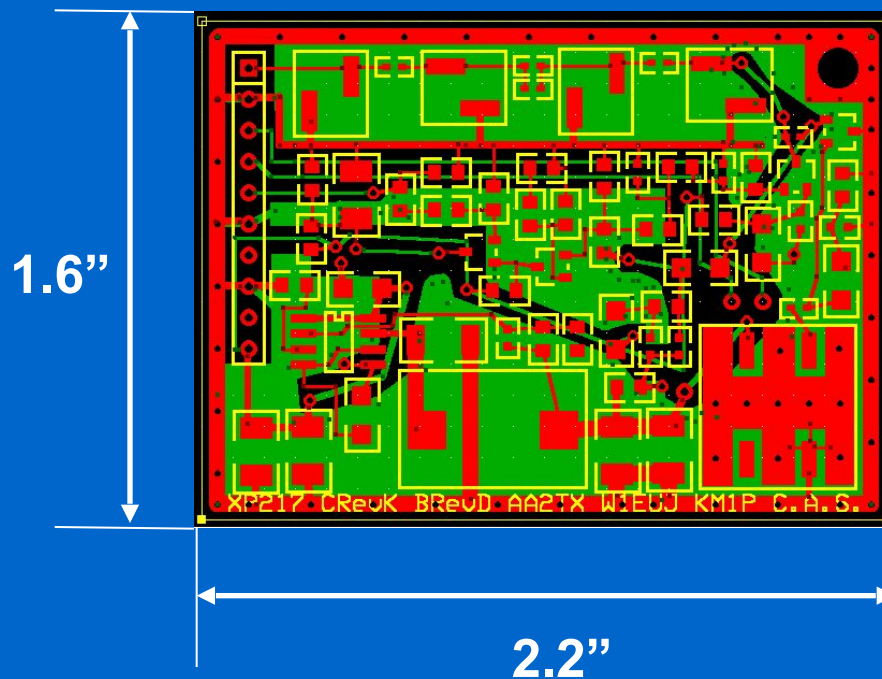


XP217 Schematic



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XP217 PC Board



XP217 Project Milestones

- **Circuit Design Completed - 9/2004**
- **Manufacture PCBs - 10/2004**
- **Build & Test first prototypes - 11/2004**
- **Integration models to USNA - 12/2004**
- **Flight models - 5/2005**
- **Launch scheduled for 12/2005**

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Questions?



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Thank You